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**Linthicum et al.**

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(54) **METHODS OF FABRICATING GALLIUM NITRIDE SEMICONDUCTOR LAYERS ON SUBSTRATES INCLUDING NON-GALLIUM NITRIDE POSTS, AND GALLIUM NITRIDE SEMICONDUCTOR STRUCTURES FABRICATED THEREBY**

**FOREIGN PATENT DOCUMENTS**

CA	2258080	10/1998
EP	0 551 721 A2	7/1993
EP	0 852 416 A1	7/1998

(List continued on next page.)

**OTHER PUBLICATIONS**

U.S. patent application Ser. No. 60/109,674, Linthicum et al., filed Nov. 24, 1998.

U.S. patent application Ser. No. 60/109,860, Gehrke et al., filed Nov. 24, 1998.

(List continued on next page.)

*Primary Examiner*—Nathan J. Flynn

*Assistant Examiner*—Victor A. Mandala, Jr.

(74) *Attorney, Agent, or Firm*—Moore & Van Allen PLLC; Steven B. Phillips

(75) **Inventors:** **Kevin J. Linthicum**, Angier, NC (US);  
**Thomas Gehrke**, Carrboro, NC (US);  
**Robert F. Davis**, Raleigh, NC (US)

(73) **Assignee:** **North Carolina State University**,  
Raleigh, NC (US)

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(56) **References Cited**

**U.S. PATENT DOCUMENTS**

4,127,792 A	11/1978	Nakata	.....	313/500
4,522,661 A	6/1985	Morrison et al.	.....	148/33.2

(List continued on next page.)

(57) **ABSTRACT**

A substrate includes non-gallium nitride posts that define trenches therebetween, wherein the non-gallium nitride posts include non-gallium nitride sidewalls and non-gallium nitride tops and the trenches include non-gallium floors. Gallium nitride is grown on the non-gallium nitride posts, including on the non-gallium nitride tops. Preferably, gallium nitride pyramids are grown on the non-gallium nitride tops and gallium nitride then is grown on the gallium nitride pyramids. The gallium nitride pyramids preferably are grown at a first temperature and the gallium nitride preferably is grown on the pyramids at a second temperature that is higher than the first temperature. The first temperature preferably is about 1000° C. or less and the second temperature preferably is about 1100° C. or more. However, other than temperature, the same processing conditions preferably are used for both growth steps. The grown gallium nitride on the pyramids preferably coalesces to form a continuous gallium nitride layer. Accordingly, gallium nitride may be grown without the need to form masks during the gallium nitride growth process. Moreover, the gallium nitride growth may be performed using the same processing conditions other than temperatures changes. Accordingly, uninterrupted gallium nitride growth may be performed.

**43 Claims, 2 Drawing Sheets**

